June 1993

Physics 30

Grade 12 Diploma Examination

Alberta
EDUCATION

June 1993

Physics 30

Grade 12 Diploma Examination

Description

Time allotted: 2.5 h
Total possible marks: 70

This is a **closed-book** examination consisting of **three** parts:

Part A
has 42 multiple-choice questions each with a value of one mark.

Part B
has 7 numerical-response questions each with a value of one mark.

Part C
has 4 written-response questions for a total of 21 marks.

A physics data booklet is provided for your reference.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Carefully read the instructions for each part before proceeding.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Do not fold the answer sheet.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Part A: Multiple Choice

42 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully and decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This diploma examination is for the subject of

A. biology
B. physics
C. chemistry
D. mathematics

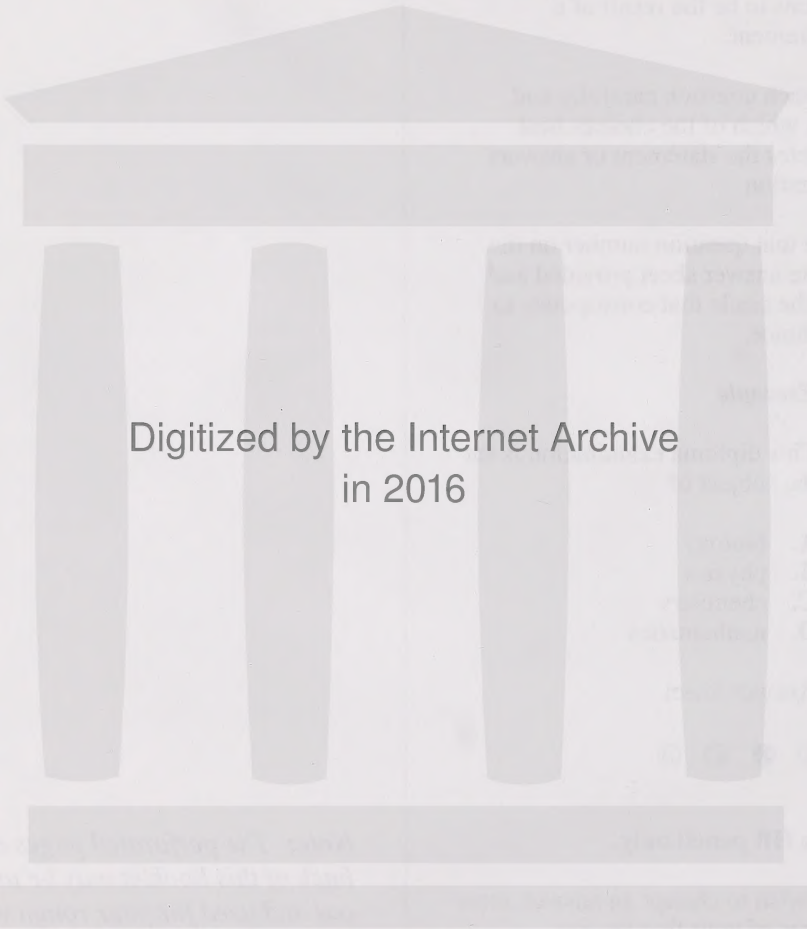
Answer Sheet

Ⓐ ● Ⓒ Ⓓ

- **Use an HB pencil only.**
- If you wish to change an answer, erase **all** traces of your first answer.

Note: *The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks*** *will be given for work done on the tear-out pages.*

Do not turn the page to start the examination until told to do so by the presiding examiner.

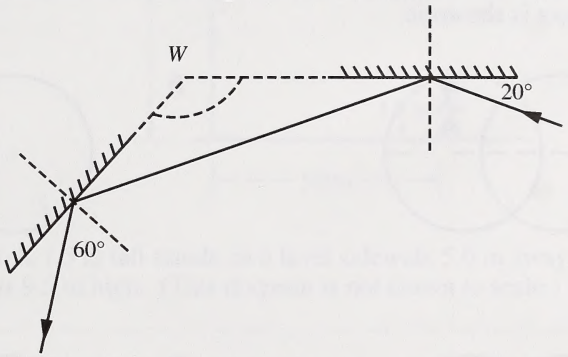


1. Which property of light is always unaffected when light enters a medium?

A. Wavelength
B. Frequency
C. Direction
D. Speed

Use the following information to answer question 2.

Multiple Reflections



A light ray reflects from two mirrors in a department store.

2. The measure of angle W is

A. 100°
B. 120°
C. 130°
D. 140°

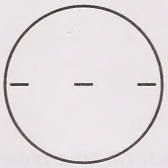
---

3. The primary colors in the Additive Theory of Light are

A. red, green, and blue
B. red, yellow, and blue
C. white, black, and grey
D. magenta, cyan, and yellow

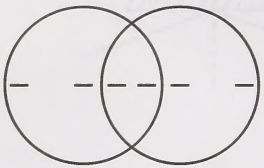
Use the following information to answer question 4.

A Polaroid™ filter has one axis of polarization. This axis is represented in the diagram:

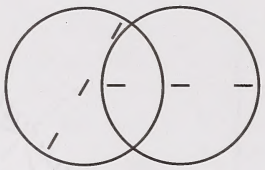


4. The orientation that allows a **minimum** amount of light to pass through two such Polaroid™ filters is shown in

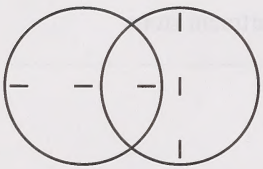
A.



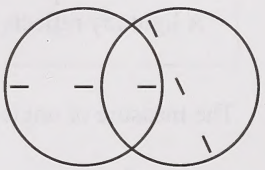
B.



C.



D.



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5. A laser pulse is reflected off the moon and is received back at the Earth transmitter 2.6 s after the pulse is sent. Using these data, the distance from the Earth to the moon is calculated to be

A. 1.6×10^9 m

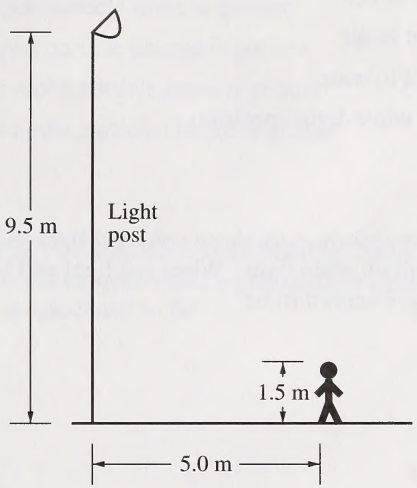
B. 7.8×10^8 m

C. 3.9×10^8 m

D. 1.2×10^8 m

Use the following information to answer question 6.

A Street Light Shadow



A girl who is 1.5 m tall stands on a level sidewalk 5.0 m away from a street light that is 9.5 m high. (This diagram is not drawn to scale.)

6. What is the length of the girl's shadow on the sidewalk?

A. 1.1 m
B. 0.94 m
C. 0.79 m
D. 0.43 m

---

7. When light rays pass by the sharp edge of a razor blade or through venetian blinds that are nearly closed, the light rays are

A. reflected
B. refracted
C. polarized
D. diffracted

8. Newton's particle theory of light was abandoned immediately after measurements were made of the

A. photoelectric effect
B. speed of light in air
C. speed of light in water
D. width of the white-light spectrum

9. A particular T-shirt absorbs only those colors of light that have wavelengths shorter than the wavelength of green light. When red light and blue light illuminate this T-shirt, its color is observed to be

A. red
B. blue
C. black
D. purple

10. The electron volt (eV) is a unit of

A. energy
B. charge
C. current
D. potential difference

11. The electron gun in the back of a black-and-white TV set has a length of 1.2×10^{-2} m and an accelerating voltage of 2.0×10^{3} V. The acceleration of the electron while in this gun is

A. 1.8×10^{35} m/s^2
B. 2.9×10^{16} m/s^2
C. 4.2×10^{12} m/s^2
D. 3.0×10^{8} m/s^2

12. An electron and an alpha particle travelling at the same speed pass through the same magnetic field. Compared to the force exerted on the electron, the force exerted on the alpha particle is

A. less because the alpha particle mass is greater

B. less because the alpha particle charge is greater

C. greater because the alpha particle mass is greater

D. greater because the alpha particle charge is greater

13. A sphere with an excess of 11 electrons is suspended between two horizontal plates 3.0 mm apart. The plates are maintained at a potential difference of 3.0×10^2 V. The mass of this sphere is calculated to be

A. 1.6×10^{-15} kg

B. 1.6×10^{-14} kg

C. 1.8×10^{-14} kg

D. 1.8×10^{-13} kg

Use the following information to answer question 14.

Operation of an Electric Motor

Voltage	2.40×10^2 V
Current	41.7 A
Efficiency	20.0%

14. If this electric motor is used to operate a hoist, how high could a 2.00×10^2 kg object be lifted in 10.0 s?

A. 5.00×10^2 m

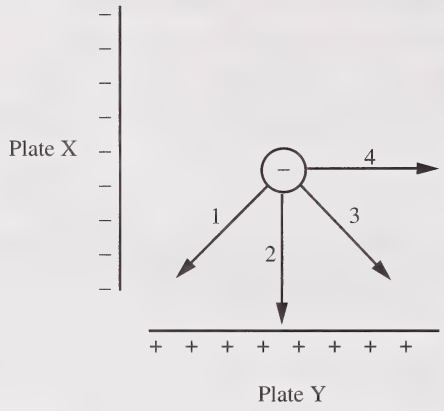
B. 1.00×10^2 m

C. 51.1 m

D. 10.2 m

Use the following information to answer question 15.

Charged Sphere in an Electric Field



A negatively charged sphere experiences a force because of the equal and opposite charges on plates X and Y.

15. The negatively charged sphere will likely move in direction

A. 1
B. 2
C. 3
D. 4

---

16. If a watch battery delivers a current of 1.0×10^{-6} A, how many electrons leave the battery every second?

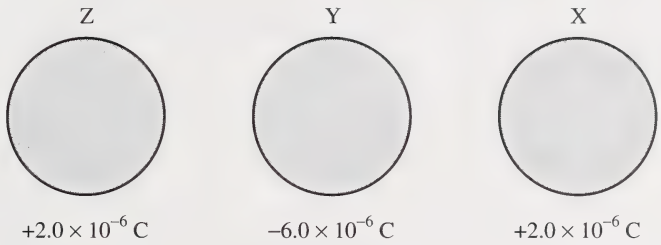
A. 6.3×10^{-25}
B. 6.3×10^{12}
C. 6.3×10^{15}
D. 6.3×10^{31}

17. The unit tesla is equivalent to the unit combination

A. N/(A•m)
B. (A•m)/N
C. (N•m)/(C•s)
D. (C•m)/(N•s)

Use the following information to answer question 18.

Charge Redistribution



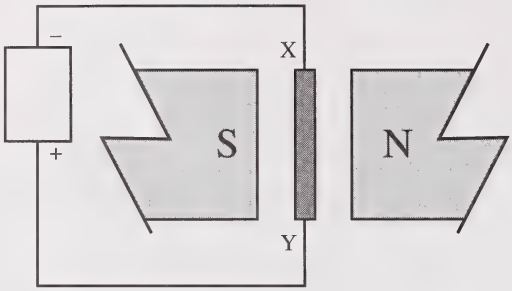
Three identical insulated metal spheres, Z, Y, and X, have their initial charges as indicated.

18. If Z is touched to Y and then to X, the charge remaining on X will be

A. -6.7×10^{-7} C
B. $+6.7 \times 10^{-7}$ C
C. -3.3×10^{-6} C
D. zero

Use the following information to answer question 19.

Wire in a Magnetic Field



Wire XY is 4.0 cm long. It carries a 0.50 A current perpendicular to a magnetic field of magnitude 6.0×10^{-4} T.

19. The force on wire XY is

A. 1.2×10^{-5} N into the plane of the page
B. 1.2×10^{-5} N out of the plane of the page
C. 3.0×10^{-4} N into the plane of the page
D. 3.0×10^{-4} N out of the plane of the page

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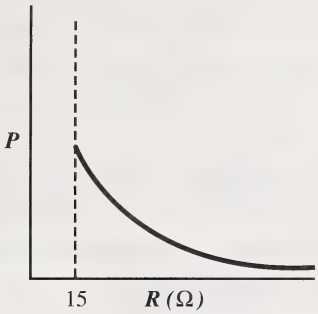
20. The direction of an electric field is defined as the direction of the force that the field exerts on a

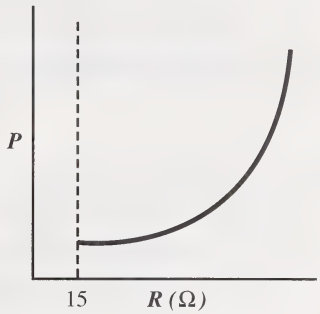
A. test mass
B. positive charge
C. negative charge
D. north magnetic pole

21. A resistor will heat up from a "cold" value of 15 Ω to a "hot" operating value of 1.0×10^2 Ω as a **constant voltage** is applied. The graph that represents the power P as a function of resistance R for this particular resistor is

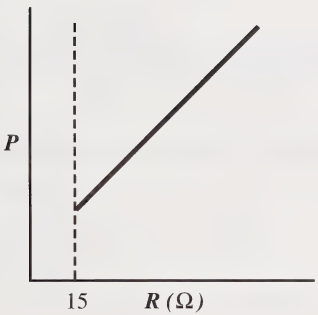
A.



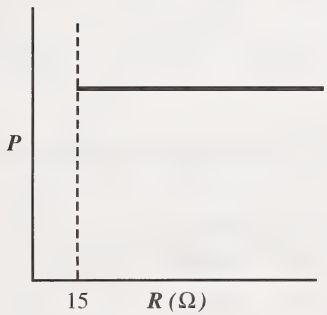
B.



C.



D.



22. An electric field that changes nonuniformly induces a changing magnetic field. This magnetic field, in turn, induces a

A. constant electric field parallel to the magnetic field

B. changing electric field parallel to the magnetic field

C. constant electric field perpendicular to the magnetic field

D. changing electric field perpendicular to the magnetic field

23. Compared with visible light, X-rays have a

A. higher speed
B. lower frequency
C. higher frequency
D. greater wavelength

24. The telephone connection between Edmonton and Calgary, a distance of 3.0×10^2 km, can be made with an optical fibre that has an index of refraction of 1.8. The **difference** in travel time between a message carried by the fibre and a message transmitted by microwaves at ground level would be

A. 1.8×10^{-3} s
B. 1.0×10^{-3} s
C. 8.0×10^{-4} s
D. 5.0×10^{-4} s

25. Electromagnetic radiation of frequency 5.00×10^{21} Hz is **best** described as being

A. radio
B. gamma
C. infra-red
D. ultraviolet

26. A radio wave travelling down a coaxial cable has a period of 1.4×10^{-9} s and a wavelength of 0.25 m. How long will it take the radio wave to travel 15 m down this cable?

A. 5.0×10^{-8} s
B. 8.4×10^{-8} s
C. 1.7×10^{-7} s
D. 4.3×10^{10} s

27. The Thomson model of the atom

A. was formulated from quantum mechanical theories
B. predicted the size of the nucleus to be about 10^{-14} m
C. was confirmed by Millikan's photoelectric experiments
D. proposed that positive material was uniformly distributed throughout the atom

28. The study of electrolysis was made possible by the invention of

A. Volta's electric cell
B. Geissler's vacuum pump
C. Ampere's current balance
D. Coulomb's torsion balance

29. A photoelectric device operates in the visible region. This device will have the most chance of working with a 60 W light bulb that emits

A. yellow light
B. green light
C. blue light
D. red light

30. If light of wavelength 2.0×10^{-6} m strikes a metal surface of work function 2.0 eV,

A. no photoelectrons will be emitted
B. photoelectrons with negligible kinetic energy will be emitted
C. photoelectrons with 2.2×10^{-19} J of kinetic energy will be emitted
D. photoelectrons with 3.2×10^{-19} J of kinetic energy will be emitted

31. Which observation is valid for all cathode rays?

A. They are positively charged.
B. They travel at the speed of light.
C. They can be polarized by refraction.
D. They have the properties of electrons.

32. How many radio wave photons of frequency 930 kHz would collectively have the same energy as one photon of yellow light of frequency 5.0×10^{14} Hz?

A. 5.0×10^{14}
B. 5.4×10^{11}
C. 5.4×10^{8}
D. 1.9×10^{-9}

Use the following information to answer question 33.

Electrolysis of Water

Trial	Mass of Hydrogen (g)	Mass of Oxygen (g)
I	8.7	69.7
II	8.0	64.0
III	6.0	48.1
IV	4.5	33.8

33. From which trial should the results be rejected as being inconsistent with the other data?

A. I
B. II
C. III
D. IV

Use the following information to answer question 34.

A beam of light from a discharge tube that contains hydrogen gas is incident normally on a diffraction grating with 2.0×10^5 lines/m. One of the Balmer lines ($n_f = 2$) forms a first-order diffraction image at an angle of 7.5°.

34. The electron transition that produces this spectral line is the transition from

A. $n_i = 3$ to $n_f = 2$
B. $n_i = 4$ to $n_f = 2$
C. $n_i = 5$ to $n_f = 2$
D. $n_i = 6$ to $n_f = 2$

---

35. The difference between the values of kinetic energy calculated using the classical formula and the values of kinetic energy calculated using the relativistic formula is most significant for

A. high speed particles
B. large mass particles
C. small mass particles
D. electromagnetic radiation

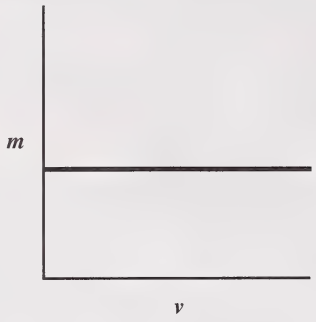
36. The Compton effect demonstrates

A. the probability of finding an electron in a specific place
B. that X-rays are not affected by magnetic fields
C. the wave-particle duality of electrons
D. that photons have momentum

Use the following information to answer question 37.

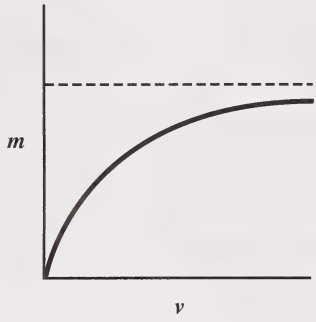
Relativistic Mass Graphs

I.

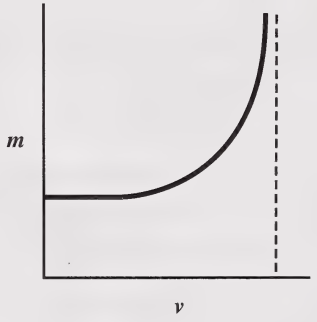


II.

III.



IV.



37. The graph that **best** represents the mass m as a function of the speed v for a particle that is accelerated to a relativistic speed is

A. I
B. II
C. III
D. IV

38. The relation $mvr = nh/(2\pi)$ seemed rather arbitrary when first used by Bohr. In 1923, de Broglie suggested that this relation is a consequence of the electron's

A. wavelength
B. charge
C. speed
D. mass

39. If an electron is known to be confined in a space that is 10^{-10} m across, then the uncertainty in the momentum of this electron is in the order of

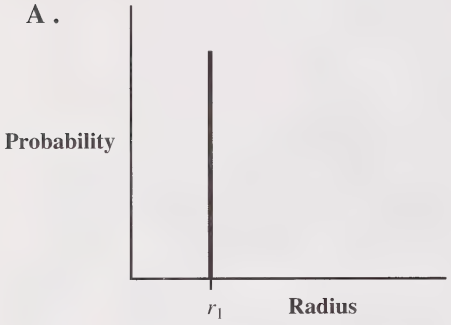
A. 10^{-35} kg • m/s
B. 10^{-24} kg • m/s
C. 10^{-18} kg • m/s
D. 10^{-6} kg • m/s

40. The photons in a monochromatic beam of light each have a momentum of 1.50×10^{-27} kg•m/s. The period of this light is

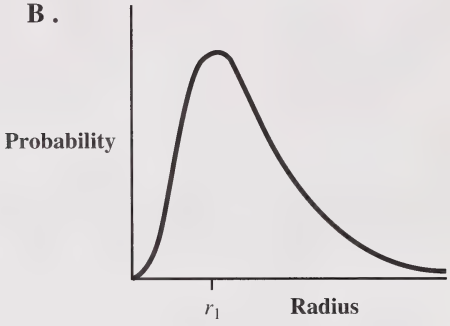
A. 1.47×10^{-15} s
B. 4.42×10^{-7} s
C. 2.26×10^{6} s
D. 6.79×10^{14} s

41. For a hydrogen atom in its ground state, r_1 represents the first Bohr radius. According to Schrödinger's wave mechanics, the diagram that **best** represents the probability of finding the electron as a function of the distance r from the nucleus is

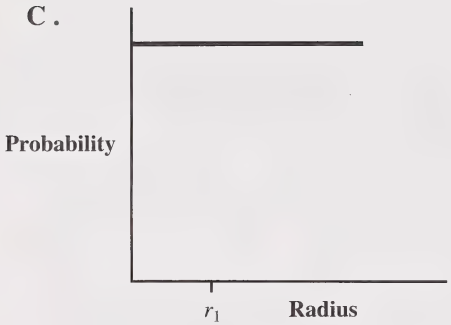
A.



B.



C.



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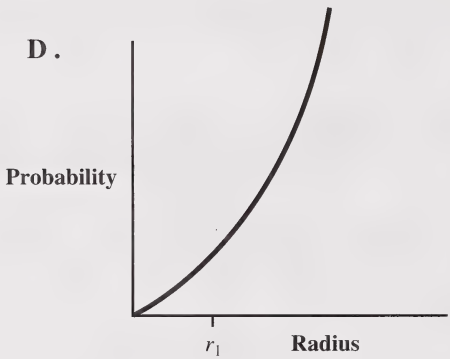


42. At what speed will the relativistic mass of a particle be exactly three times its rest mass?

A. 1.00×10^8 m/s

B. 2.00×10^8 m/s

C. 2.67×10^8 m/s

D. 2.83×10^8 m/s

You have now completed Part A. Proceed directly to Part B.

Part B: Numerical Response

7 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**
- Use an HB pencil only.
- If you wish to change an answer, erase **all** traces of your first answer.

Sample Questions and Solutions

If the angle of incidence in air is 47.6° and the angle of refraction is 28.3°, the index of refraction is _____.
(Round and record your answer to three digits.)

$$n = \frac{\sin \theta_1}{\sin \theta_2}$$

$$n = \frac{\sin 47.6°}{\sin 28.3°} = 1.5576328$$

Record 1.56 on the answer sheet →

A microwave of wavelength 16 cm has a frequency of $b \times 10^9$ Hz. The value of b is _____.
(Round and record your answer to two digits.)

$$f = c/\lambda$$

$$= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m})$$

$$f = 1.875 \times 10^9 \text{ Hz}$$

Record 1.9 on the answer sheet →

Start Part B immediately.

1. A beam of infra-red radiation has a frequency of 2.12×10^{13} Hz. When this beam travels in a medium of refractive index 1.61, its wavelength, expressed in scientific notation, will be $\boldsymbol{b} \times 10^{-w}$ m. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

2. A particle of charge 3.52×10^{-6} C moves at 5.10×10^{6} m/s perpendicular to a magnetic field of magnitude 4.65×10^{-4} T. The magnitude of the deflecting force, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ N. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

) YOUR ANSWER ON THE ANSWER SHEET

3. An observer moves away from a light source at a speed of $0.600c$. The speed of light as measured by this observer is $\boldsymbol{b} \times 10^{8}$ m/s. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

4. Light travelling through a certain medium has a wavelength of 5.51×10^{-7} m ar
frequency of 3.42×10^{14} Hz. The refractive index of this medium is _____
(Round and record your answer to three digits.)

5. A 10.0 A current flows for 15.0 min through a solution containing Mg^{2+} ions.
mass of magnesium deposited in this electrolysis is _____ g.
(Round and record your answer to three digits.)

6. A bullet of mass 10.0 g travelling at a speed of 8.00×10^2 m/s has a de Broglie wavelength, expressed in scientific notation, of $\boldsymbol{b} \times 10^{-w}$ m.
The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

7. The relativistic mass of an electron travelling at a speed of 2.40×10^8 m/s is $\boldsymbol{b} \times 10^{-30}$ kg. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

You have now completed Part B. Proceed directly to Part C.

Part C: Written Response
4 Questions

Instructions

- Consider all numbers used in the questions to be the result of a measurement.
- Read each question carefully.
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers **must show all** pertinent explanations, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences for a written response, and correct units and significant digits for a numerical response.

Note: *The perforated pages at th back of this booklet may be torn out and used for your rough work* ***No marks*** *will be given for work done on the tear-out pages.*

Start Part C immediately.

For Department Use Only

(4 marks)

1. A radio station uses two antennas that are equidistant from the main transmitter. The main transmitter broadcasts a steady tone at a frequency of 6.00×10^5 Hz.

a. Calculate the wavelength of the emitted signals.

b. A home is 19.2 km from one antenna and 23.7 km from the other. If a receiver in the home is tuned to the radio station, is the reception likely to be good or bad? Show supporting calculations or give supporting statements for your answer.

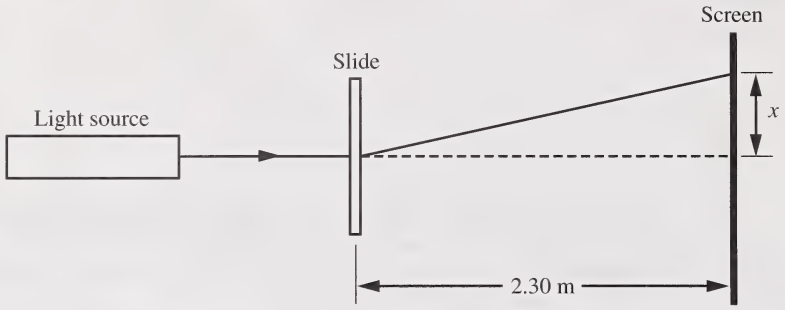
c. What property of electromagnetic radiation is used in answering part **b** of this question?

For Department Use Only

(6 marks)

Use the following information to answer question 2.

Using two razor blades taped together, a student made a double slit on a carbon-coated glass slide. The student then shone light of various known wavelengths through the slits and measured the distance x from the central maximum to the first-order bright fringe as it appeared on a screen 2.30 m from the slide.



The student recorded the following data:

λ (10^{-7} m)	4.2	5.1	5.8	6.4	6.9
x (10^{-2} m)	1.9	2.3	2.7	2.9	3.2

2. a. Graph the student's data on the following grid, placing the manipulated (independent) variable on the horizontal axis.

b. Calculate the slope of the graph.

c. Use the slope or another suitable averaging procedure to determine the best estimate of the separation of the slits. Express your answer to two significant digits.

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(5 marks)

Use the following information to answer question 3.

A uniform magnetic field B exists in the region between the poles of an electromagnet. A beam of protons with kinetic energy E_k enters the region at right angles to the magnetic field.

3. **a.** Each proton has an energy of 4.60×10^5 eV and the magnitude of the magnetic field is 0.211 T. Calculate the radius of the proton orbit, assuming nonrelativistic conditions.

b. Starting from equations in the data booklet, derive an algebraic expression for the radius of the orbit in terms of the magnetic field B, the mass m, the charge q, and the kinetic energy E_k.

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(6 marks)

Use the following information to answer question 4.

A negatively charged ebonite rod was inserted into a beaker containing a number of neutral carbon-coated pith balls. The following observations were made:

1. First, when the ebonite rod was placed close to the pith balls, the pith balls were attracted to the rod.
2. Next, the pith balls remained in contact with the rod for a fraction of a second.
3. Finally, the pith balls jumped away from the rod.

4. Explain these observations in terms of charge distributions and electrostatic forces. You **may** use diagrams as part of your explanation.

You may continue your explanation on page 29.

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You have now completed the examination.
If you have time, you may wish to check your answers.

Tear-out Page

No marks will be given for work done on this page.

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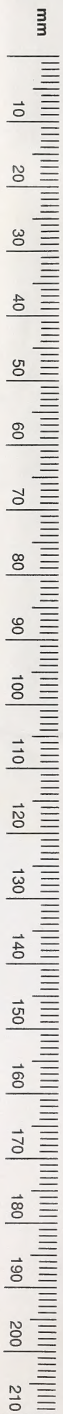

Physics 30
June 1993

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